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SCIENTIFIC METHOD IN THE RECONSTRUCTION OF NINTH-GRADE MATHEMATICS

A Complete Report of the Investigation of the Illinois Committee on Standardization of Ninth-Grade Mathematics, 1913–1918. By HAROLD ORDWAY RUGG, Associate Professor of Education, University of Chicago; and JOHN ROSCOE CLARK, Chairman, Department of Mathematics, Parker High School, Chicago. The University of Chicago Press, Chicago, Illinois.

AN EVALUATION BY WILLIAM BISHOP OWEN
Principal, Chicago Normal School

This monograph marks an epoch in the process of educational reorganization and reconstruction in America that began about a decade ago and that promises to result not only in a new and scientific curriculum but also in the establishment of sound methods of securing further progress. This is very great praise, but it is not too great. This review will attempt to justify the judgment expressed by pointing out the factors which contribute to the peculiar value the study has for the present situation in American public-school education.

There are three great influences at work in American education to which must be ascribed the changes already made and those clearly seen in prospect. These influences are (1) the social point of view represented by sociology and social psychology, (2) applied psychology particularly in the field of learning, statistics, and biometric measurements, and (3) the experimental method as a conscious technique of investigation in any field. The theory and practice of our schools has been largely empirical. Our curricula, especially in the high school, represent traditional values. Until recently there has been no adequate point of view, no recognized scientific apparatus to be used in constructing a curriculum and in guiding school practice. The significance of the work of Mr. Rugg and Mr. Clark lies in the way in which the results of these three departments of science have been used to solve a very difficult problem. It is the *combination* of the methods of these sciences in such a way as to show how they are mutually helpful and reciprocally corrective that constitutes the *contribution* of the authors and that has made their work a pioneer in the field of curriculum-making. The social point of view is maintained throughout in determining the origin, purpose, and value of the content of the mathematical curriculum, the assured results of the psychology of the learning process are applied in the treatment of the development of abilities through drill, and the experimental and statistical methods are utilized in solving the problems of distribution of emphasis, elimination of worthless material, and testing results. The authors have thus brought the social point of view into a practical work-a-day union with the science of psychology thus forging a tangible apparatus and procedure of curriculum determination. It is this simultaneous utilization of the three great foundations on which a scientific education can be built, as has been said before, that constitutes the distinction and value of the monograph.

There are ten chapters in the book which contains also an appendix and an index. Chapter i raises the problem. Ninth-grade mathematics is on trial. The public condemns it, the percentage of failures is an indictment of it, and standardized tests show that it is inefficient. The remaining chapters are given over to the report of investigations carried on by the authors to find out where the trouble lies—in the pupil, the teaching, the course of study, or in what.

Chapter ii contains a detailed inventory of the ninth-grade course in mathematics. The investigations of Koos are used to show that there is a great uniformity throughout the country in the location of beginning algebra in the ninth grade, in the length of time it is studied, and in the methods of the classroom. "Textbooks dominate the content and organization of courses in mathematics," is the key to the situation. And these textbooks have been written by college men, not by the school men who teach the class, and therefore are alone intimately in contact with the problem. A further analysis shows that the actual course determined by the textbook is chiefly devoted to formal as contrasted with "thought" problems. The authors enunciate, in the way of contrast, their mathematical creed—surely a sound one: "We teach mathematical subjects in the public schools to *develop in the pupil the ability to use intelligently the most powerful devices of quantitative thinking: the equation, the formula, the graph, and the properties of the more important space forms.*

Chapter iii tells us how algebra became the ninth-grade course. It is an interesting if brief outline of the history of the transfer of algebra from the later years of the American college course to the first year of the high-school course. Along with this change of the position of algebra in the course there went a development in method and content. Yet this change was not in the direction of simplification, as one might suppose, but rather one of enlargement and increased formality. It is high time, therefore, that the content of this first-year high-school course be scrutinized and consciously reorganized from an educational standpoint.

Chapters iv and v proceed to attack the problem of reorganization of ninth-grade algebra. The authors set forth their fivefold program. This program comprises five steps: the determination of general aim and outcomes, the clear-cut classification of subject-matter, the design and conduct of tests, the critical evaluation of the results of the tests, experimental teaching. These chapters are largely devoted to the discussion of the use of standardized tests. The authors find three functions for these tests: (1) classifying or grading children, (2) diagnosis revealing weaknesses, (3) supervising and marking. Each of these functions is clearly and adequately discussed. These chapters form an excellent brief treatment of the types and fundamental scientific bases of standard tests.

Chapter vi is a summarized report of the results of the investigation begun in 1913 by a committee of the Mathematics Section of the University of Illinois High-School Conference. The general progress of the investigation is outlined and the results clearly summarized. The chapter is indispensable for every serious student of the problems of high-school teaching.

Chapter vii is devoted to training in logical thinking. It contains an analysis of the thought process, discusses the meaning of "attitude," reviews the whole question of "transfer," and points out the opportunities afforded by the study of algebra for developing those attitudes, skills, habits, and concepts which can be used in the solution of new problems. The "problem-project-method" is *implicitly* recognized as fundamental to the educational use of mathematics. The chapter is clear, well written, is in accord with the work of Dewey, Thorndike, and others, and might well serve as an introduction to the discussion of the educational value of the study of mathematics while serving to outline its subordinate aims and outcomes.

Chapter viii deals more specifically with curriculum-making in secondary mathematics. It lays down two criteria for determining the content of the course—the social criterion and the psychological criterion. The former has been used in many of the attempts at remaking the course of study, the latter has received little satisfactory study. A review is made of the well-known recent attempts to reorganize the subject-matter of the high-school course in mathematics. This review is a good piece of criticism. The observation that "ninth-grade mathematics will certainly come to be regarded by school men in our generation as the last year of mathematics that will be required" is true and significant. "Hence the importance of including in this last year the most important mathematical notions and devices." The authors proceeded to ascertain what are most important by finding what of the current first-year algebra is used (1) in further high-school subjects such as physics, chemistry, and the like, and (2) in the industrial occupations. The results are presented with definiteness and at length and will serve as an invaluable reference. The conclusion reached is set forth in the following paragraph:

> To build such a course clearly demands the elimination of one-third to one-half of the present ninth-grade course. Note the economy of time through elimination of nonessentials. We shall save at least four weeks on special products and factoring, two to four weeks on the formal manipulation of addition, subtraction, multiplication, and division, a week on highest common factor and least common multiple, at least one week (probably two) on fractions, between one and two weeks on quadratic equations, between one and two weeks on radicals.

Chapter ix is a report of experiments conducted by the authors to determine how pupils can best learn algebra. The results cannot easily be reproduced in this review but should be studied for their significance and promise. They are sufficiently interesting to lead one to await with interest the fuller report of the completed experiment. The experiment itself may easily prove to be the most valuable contribution made by the authors.

Chapter x is a résumé of the preceding chapters and their conclusions with an appeal for co-operation in the working out of an educational course in mathematics for the ninth grade.

It is almost ungracious to suggest that the style of the monograph is not always as simple and compact as one could wish. There is a great deal of unnecessary repetition. But these are minor and perhaps negligible defects. The authors have done the American schools a real and lasting service. They have shown how to go to work to reorganize the curriculum of these schools. In these days of overcrowding, of competing claims, of subjective opinion, of persistent demand for reorganization, theirs is indeed a piece of genuine pioneer work.